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Hydraulics

3rd Year civil

First Term (2009 - 2010)

Chapter ( )

Revision Part (2)
final 2005

University of Zagazig
Faculty of Engineering
Water Eng. Dept.

Final Ex.

Hydraulics
Time. 3 Hr
January, 2005

Solve as much as you can. (N.B. Any missing data can be reasonably assumed).

Question 1-

A- Sketch the velocity distribution over a smooth channel surface, comment very briefly.

B- Plot the isovels for very wide and very narrow rectangular channel and explain how the boundary resistance affects on the velocity distributions, then sketch samples of verticals and lateral velocity distributions for each one.

C- Draw the relationship between C, and n when the hydraulic radious is constant.

D- Sketch the hydraulic jump interpreted by specific energy and specific force diagrams, express and show few of the hydraulic jump characteristics.

E- What is the minimum slope at which 28 m^3/sec may be carried out uniformly at a mean velocity of 0.6 m/sec in a trapezoidal canal having n=0.025 and side slopes 1 (vertical): 2 (Horizontal)? Redesign for hydraulically stable section, if the maximum velocity is 0.4 m/s, d_{50} = 0.15 mm.

Question 2-

A- Discuss very briefly about:
Control volume, Control section, State of flow, regime of flow.

B-Demonstrate the effect of a sudden rise in the bed of an open channel Appling the specific energy analysis for different approaching flow conditions, showing the limiting case.

C- Plot b/P versus the slope of sides for trapezoidal channel in case of best hydraulic section in which b is the bed width and p is the wetted perimeter. Sketch τ_0 distribution for a selected case.

d- A hydraulic jump was formed in a rectangular open channel of width 4.0 m, has its sides expanding 0.3 m from each side at a given section, if the two conjugate depths are 0.50 m and 6.0 m respectively. And the depth of water downstream the contracted part is 4.50 m. calculate the discharge passing, power dissipated by the jump in K, wt, and the overall efficiency of the hydraulic jump.

Question 3-

A- Classify the water surface profiles according to the bed slope, give practical examples for each.

B- What is meant by "stilling basin" using a sketch, explain how to control the location of the jump in an open channel.

C- A uniform flow occurs in a very long rectangular channel, the normal water depth is 0.9 m and the mean velocity is 4.8 m/sec. A vertical sluice gate is constructed and lowered so that the opening is 0.60 m. sketch the new water surface profiles to be expected and identify them by letter and number. Calculate and show all significant depths and expected T.E.L. noting that the normal water depth D.S. the gate exert when the mean velocity equals to 0.8 m/s. (assuming n=0.025).

Question 4-

A- State the advantages and disadvantages of hydraulic modeling.

B- What is meant by "complete dynamic similarity" for hydraulic modeling? Give one practical example.

C- Select any hydraulic phenomenon then write all forces affecting upon this phenomenon, deduce all dimensionless groups which controlling it, and show how the selected dimensitionless parameters are correlated.

D- Drive an expression for Manning coeff. ratio n_r, Chezy coeff. ratio C_r and shear velocity ratio U_* for open channel flow, according to certain scale ratio.

Question 5-

A- If the energy loss through a channel reach can be neglected, what type of flow would be expected?

B- State why the dimensional analysis is necessary?

C- List the different practical methods used to measure flow rates in open channels and very wide rivers?derive an expression for critical depth meter?

D- A model was constructed with scale ratio 1:20 to study the problem of energy dissipater. By means of theory of least squares determine the constant in: $\frac{y_2}{y_1} = aF_1 + b$ for the following results.

Y_1 (cm)	1.44	2.25	3.47	3.99
Y_2 (cm)	9.81	10.89	17.92	19.99
Q (lit/sec)	5.9	7.48	16.31	19.51

If the rectangular channel width =0.3 m, then find the relative depth of hydraulic jump at Q=18.1 Lit/sec and y_1=2.4 cm.

E- find the discharge passing in the prototype at inflow Froude number =3.0 and y_1=3.6 cm, then find the sequent depth of the jump.

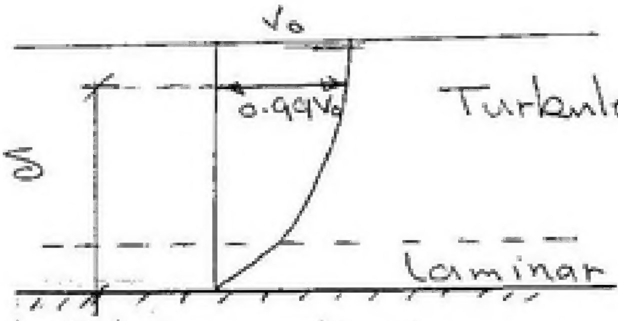
F- Using the dimenstional analysis, correlate all involved variables affecting such phenomenon..

بسم الله الرحمن الرحيم

Final 2005

Q(1):

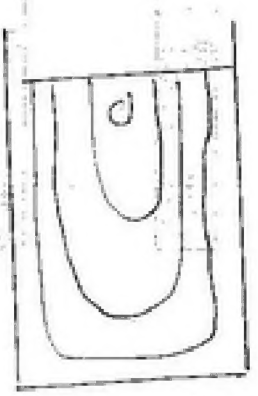
(A):



بالقرب من قاع المجرى المائي يظل السريان شرائحي نظراً
لانخفاض قيمة السرعة . وكلما ابتعدنا تزداد السرعة
ويتحول السريان إلى سريان مضطرب

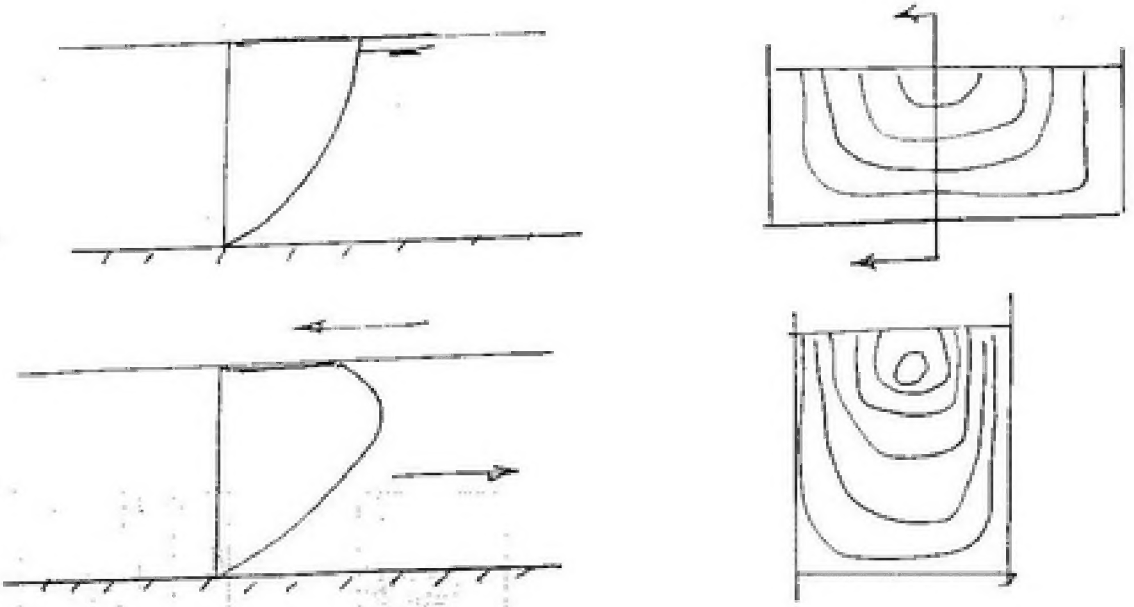
(B):

V. deep
V. narrow



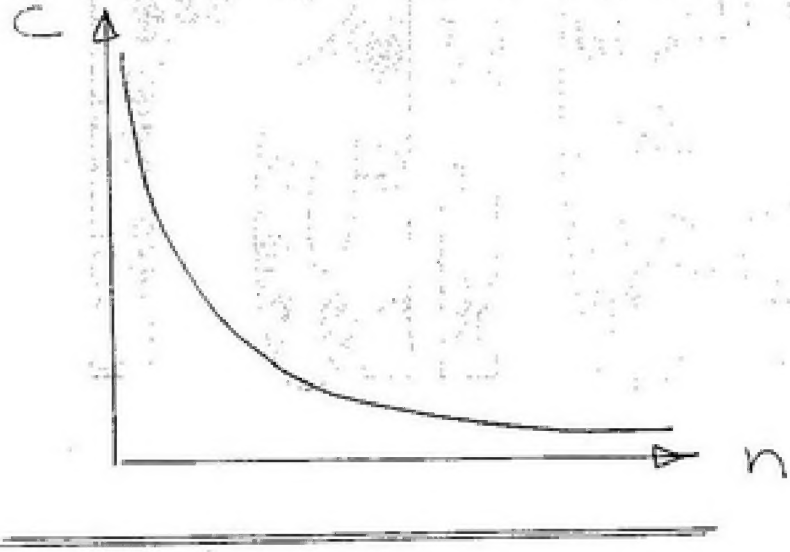
V. wide
V. shallow

- الاحتكاك بجوانب المجرى المائي تقلل من قيمة السرعة
وكلما ابتعدنا عن حدود المجرى المائي قل تأثير الخشونة
وزادت قيمة السرعة .

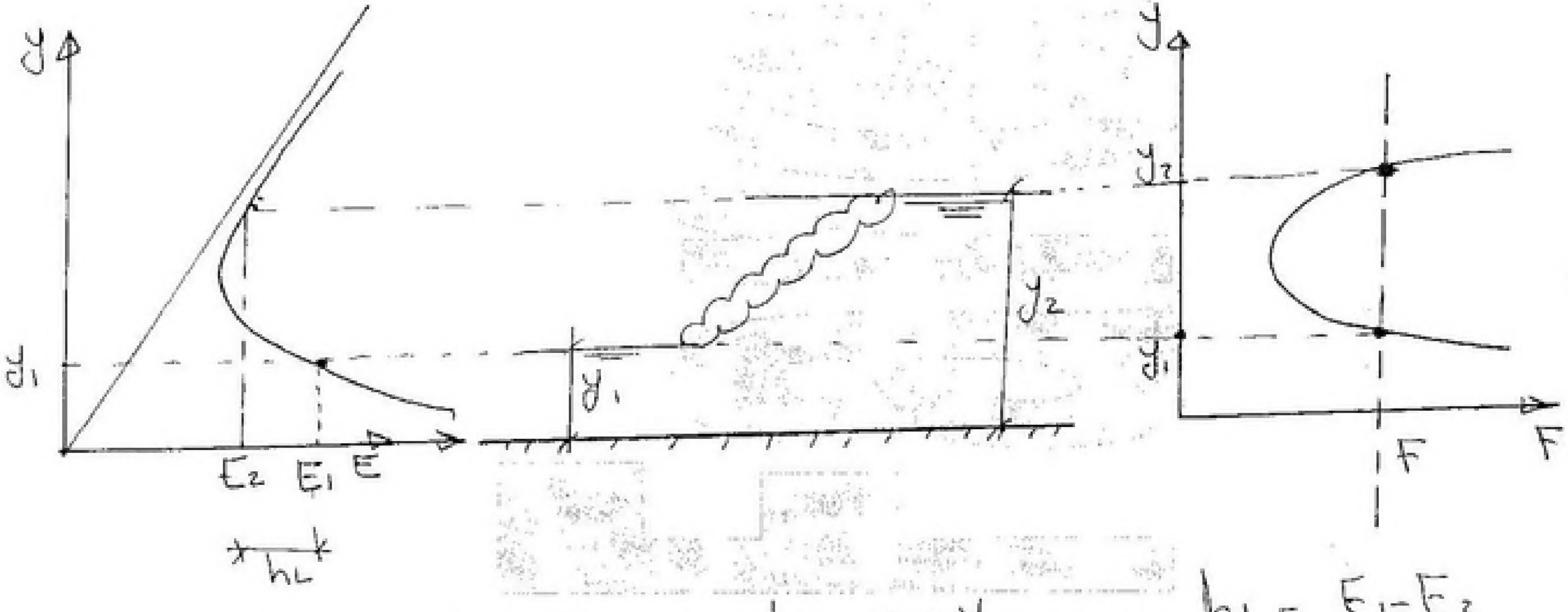


(C):

$$C = \frac{1}{n} R^{1/6}$$



(D):

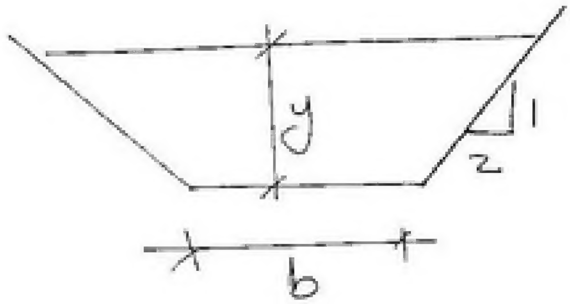


$H_j = y_2 - y_1$, $L_j = 5.2\, y_2$, $h_L = E_1 - E_2$

$\eta = \frac{E_2}{E_1}$, $\frac{y_2}{y_1} = 0.5\left[\sqrt{1+8F_1^2} - 1\right]$

(E) :

- $Q = 28\ m^3/s$
- $V = 0.60\ m/s$
- $n = 0.025$



Req. (a) find min. slope

(b) Redesign section

$V = 0.4\ m/s \qquad d_{50} = 1.5\ mm$

Sol. :

$$\because Q = \frac{1}{n} \cdot \frac{A^{5/3}}{P^{2/3}} \cdot S^{1/2}$$

for min. slope B.H.S

$$R = \frac{y}{2} = \frac{A}{P}$$

$$A = (b + zy)\,y = (b + 2y)\,y$$

$$P = b + 2y\sqrt{1+z^2} = b + 4.47y$$

$$\therefore \frac{\cancel{y}}{2} = \frac{(b+2y)\cancel{y}}{b+4.47y}$$

$$b + 4.47y = 2b + 4y$$

$$b = 0.47y \longrightarrow 1$$

$$\therefore A = \frac{Q}{V} = \frac{28}{0.6} = 46.7\,m^2$$

$$46.7 = (b + 2y)y \longrightarrow 2$$

from 1 in 2

$$46.70 = (0.47y + 2y)y$$

$$46.7 = 2.47\,y^2$$

$$y = 4.35\ m$$

$$b = 2.05\,m$$

$$P = 2.05 + 4.47 \times 4.35 = 21.50\,m$$

$$\therefore 28 = \frac{1}{0.025} \times \frac{(46.7)^{5/3}}{(21.5)^{2/3}} \times S^{1/2}$$

$$S = 0.0001 \quad \#$$

$Q = 28\ m^3/S$

$V = 0.4\ m/S$

$d_{50} = 1.5\ mm$

$S = 0.0001$

assume $b/y = 6$

$\tau_s = 0.75\ \gamma \cdot y \cdot S$

$\tau_b = 0.97\ \gamma \cdot y \cdot S \leq \tau_{cr}$

$\tau_{cr} = 0.15\ kg/m^2$

$\therefore 0.15 = 0.75 \times 1000 \times y \times 0.0001$

$y = 2.0\ m$

$0.15 = 0.97 \times 1000 \times y \times 0.0001$

$y = 1.55\ m$

$y = 1.55\ m$

$b = 9.30\ m$

$\because Q = A \times V$

$A = (9.3 + 2 \times 1.55) \times 1.55 = 19.2$

$Q = 19.2 \times 0.4 = 7.70\ m^3/s < 28$

assume $\frac{b}{y} = 10$

$y = 1.55 \quad , \quad b = 15.5\ m$

$A = (15.5 + 2 \times 1.55) \times 1.55$

$A = 28.8$

$Q = 0.4 \times 28.8 \quad < 28$

حل آخر

$\because Q = A \times V$

$28 = A \times 0.4$

$A = 70\ m^2$

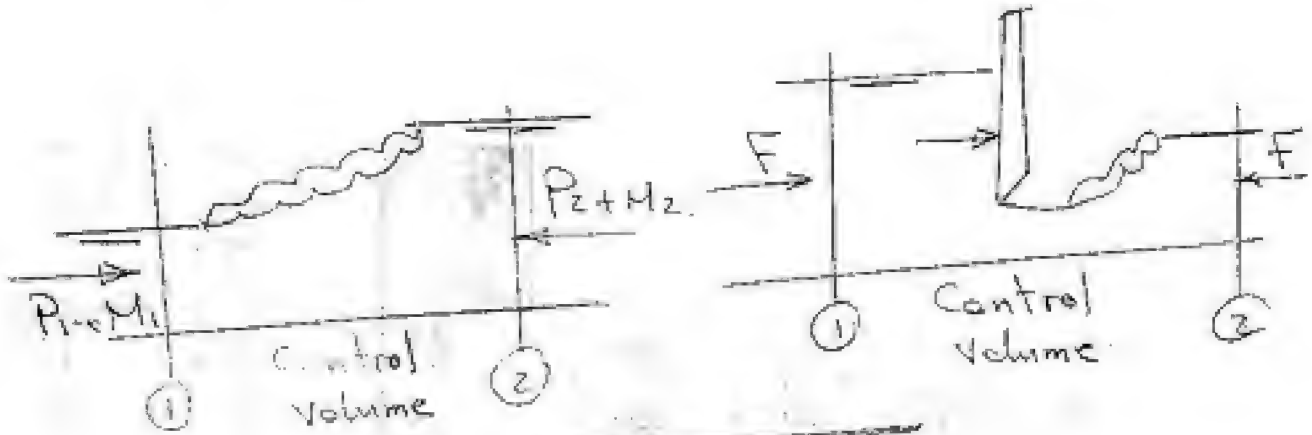
$70 = (b + 2 \times 1.55) \times 1.55$

$b = 42.0\ m$ #

Q (2) :

Control volume:

هو المنطقه من المجرى المائى التى يتم فيها عمل اتزان للقوى داخله



Control section

هو القطاع الذى يكون عنده السريان فيه هو العمق الحرج (y_c)

ممكن الاستفاده منه فى حساب التصرف

State of flow:

هو تصنيف يعتمد على (Rn)

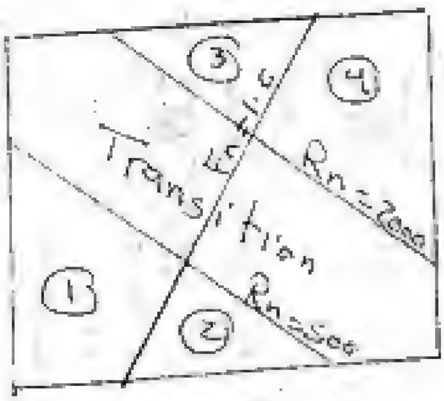
Turbulent $R_n > 2000$

laminar $R_n < 500$

Transition $500 < R_n \leqslant 2000$

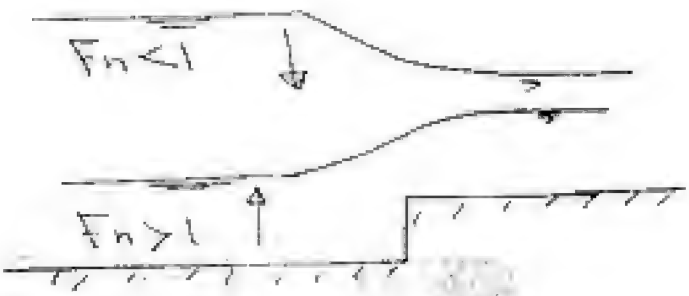
Regimes of flow

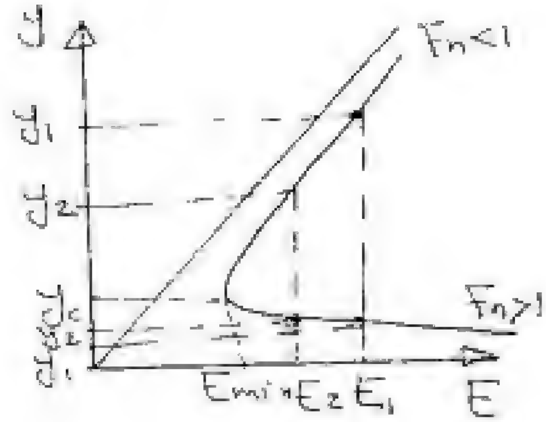
تصنيف يعتمد على R_n ، F_n معا



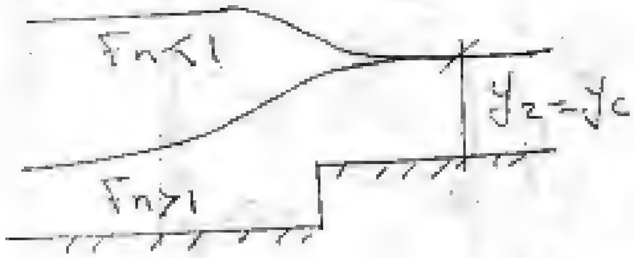
1. laminar - sub Critical
2. " - super "
3. Turbulent - sub - "
4. " - super

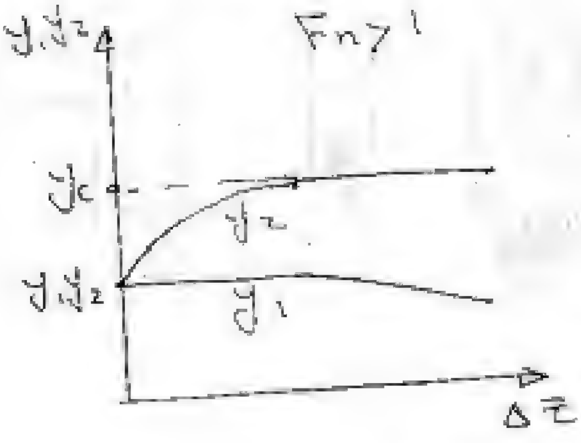
(B):

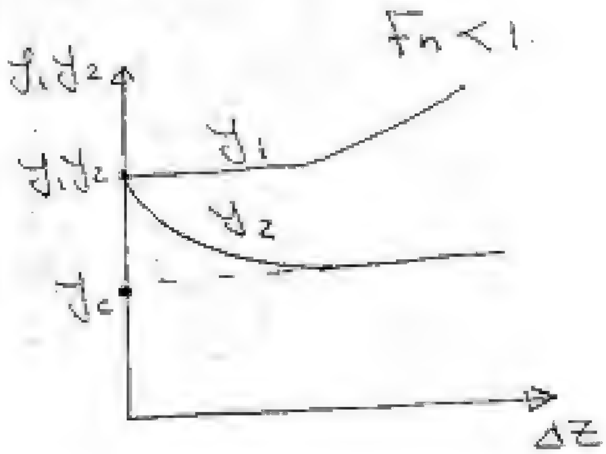

Fn<1
Fn>1


y
Fn<1
y1
y2
Fn>1
Emin E2 E1
E

Limit:


Fn<1
y2 = yc
Fn>1


y1 y2
Fn>1
yc
y2
y1 y2
y1
ΔZ


Fn<1
y1 y2
y1
y1 y2
y2
yc
ΔZ

(C) :

$\frac{b}{p}$, Z for B.H.S of trapizoidal

$$R = \frac{y}{2} = \frac{A}{P} = \frac{(b+Zy)y}{b+2y\sqrt{1+Z^2}}$$

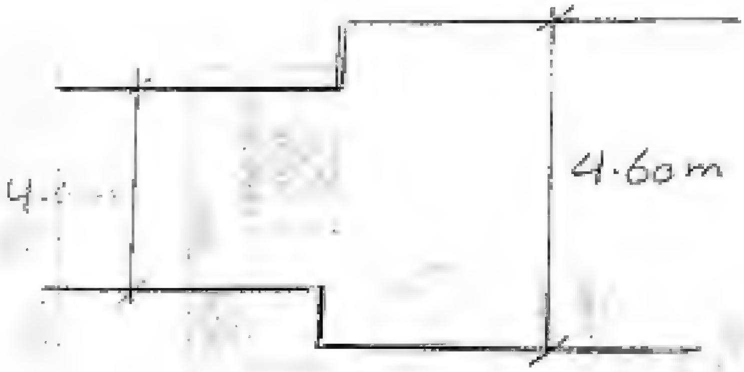
$$\frac{\cancel{y}}{2} = \frac{(b+Zy)\cancel{y}}{P}$$

$$P = 2b + 2Zy$$

$$\frac{P}{b} = 2 + \frac{2Zy}{P} \Rightarrow \boxed{\frac{b}{P} = \frac{1}{2 + \frac{2Zy}{P}}}$$

(d):

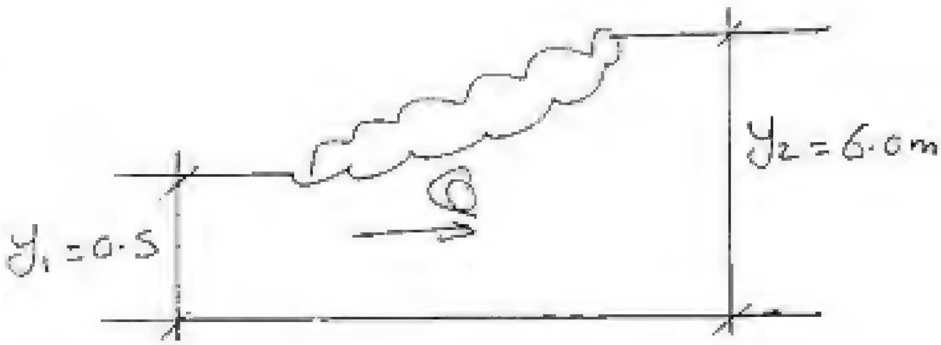
$b = 4.0\,m$



$y_1 = 0.50m$, $y_2 = 6.0m$

Req.: - Q = ??
- power dissipated
- η

Sol.:



$$P_1 + M_1 = P_2 + M_2$$

$$\gamma h_1' \cdot A_1 + \frac{\gamma Q^2}{g A_1} = \gamma h_2' \cdot A_2 + \frac{\gamma Q^2}{g A_2}$$

$$A_1 = 4 \times 0.5 = 2\,m^2$$

$$h_1' = \frac{y_1}{2} = \frac{0.5}{2} = 0.25$$

$$A_2 = 4.6 \times 6 = 27.60\,m^2$$

$$h_2' = \frac{y_2}{2} = \frac{6}{2} = 3.0$$

$$1 \times 0.25 \times 2 + \frac{1 \times Q^2}{9.81 \times 2} = 1 \times 3 \times 27.6 + \frac{1 \times Q^2}{9.81 \times 27.6}$$

$$Q = 41.72\,m^3/s \quad \#$$

$$E_1 = y_1 + \frac{V_1^2}{2g}$$

$$V_1 = \frac{41.72}{2} = 20.86\,m/s$$

$$E_1 = 0.5 + \frac{20.86^2}{2 \times 9.81} = 22.68\,m$$

$$E_2 = y_2 + \frac{V_2^2}{2g}$$

$$V_2 = \frac{Q}{A_2}$$

$$= \frac{41.72}{27.6} = 1.52 \text{ m/s}$$

$$E_2 = 6 + \frac{(1.52)^2}{2 \times 9.81} = 6.12 \text{ m}$$

$$\eta = \frac{E_2}{E_1} = \frac{6.12}{22.68} = 0.2698 \ \#$$

$$h_L = 22.68 - 6.12 = 16.56 \text{ m}$$

$$\text{Power} = \frac{\gamma Q h}{75 \times \eta}$$

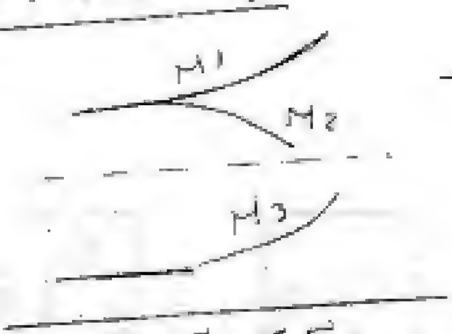
$$= \frac{1000 \times 41.72 \times 16.56}{75 \times 0.2698}$$

$$\text{Power} = \quad \text{H.P} \ \#$$

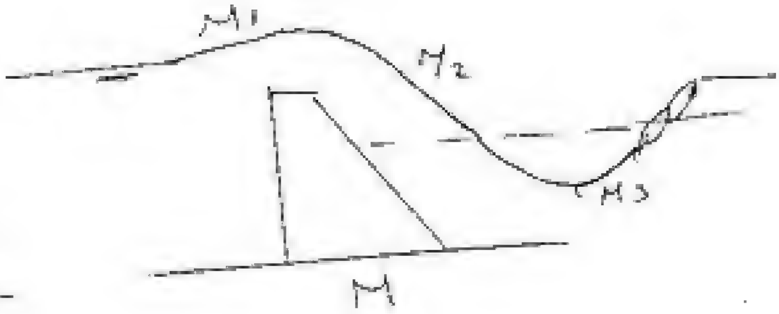
Q (3):

(A):

(1) Mild slope

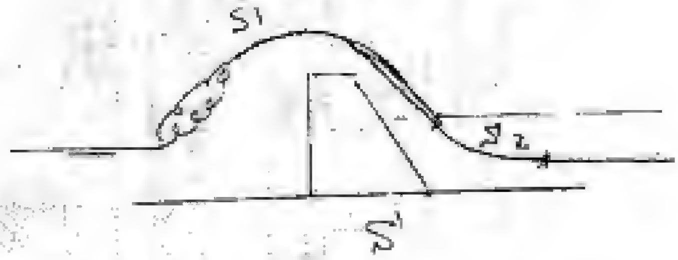


$S_0 < S_c$



(2) steep slope:

$S_0 > S_c$



(3) Critical

(4) Horizontal

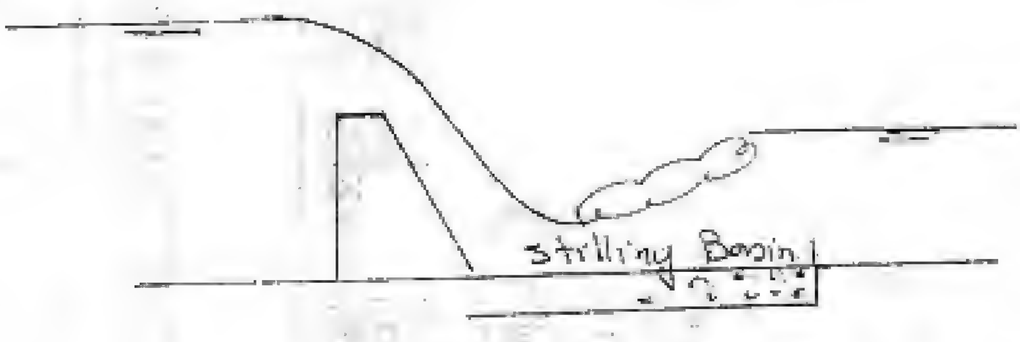
(5) adverse

(B) :

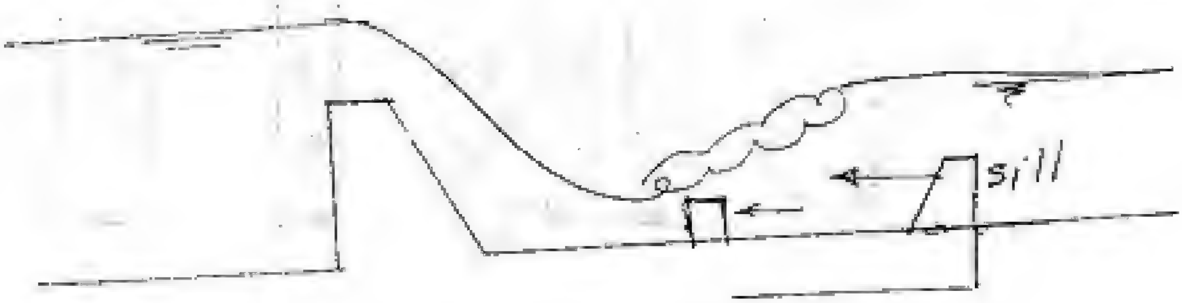
Stilling Basin :

حوض التهدئة

هي المنخفض من القناة التي يتم فيها تشتيت جزء
من طاقة الحركة لتهدئة السريان ، ويوجد
خلف المنشأة مباشرة .



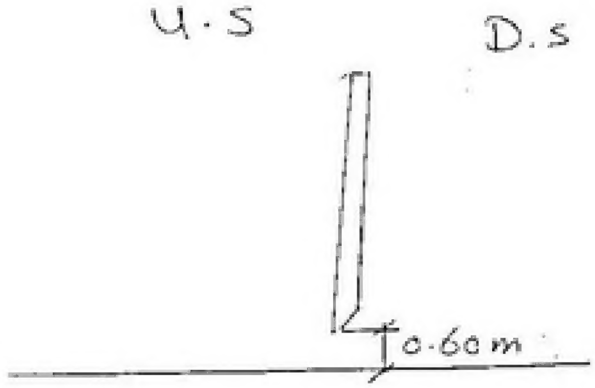
to control location of H.J use sill



(C):

$y_n = 0.90\,m$

$V = 4.8\ m/S$

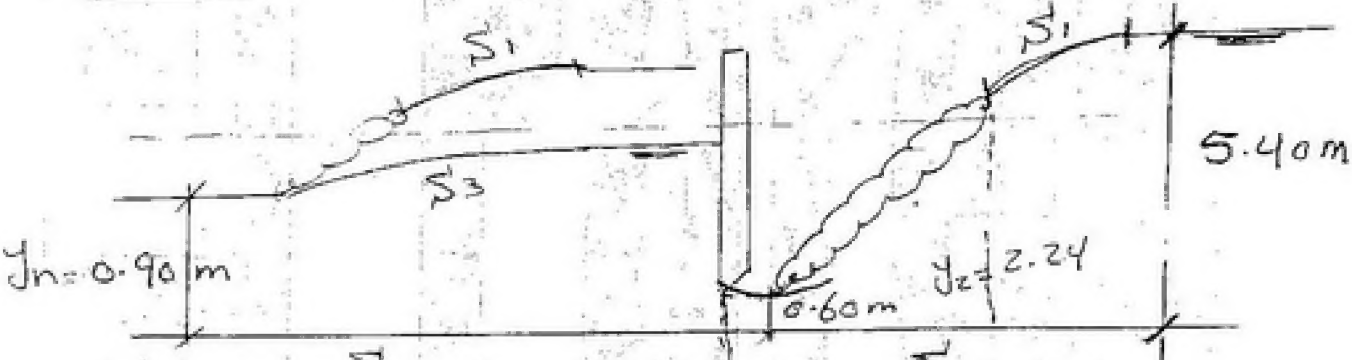


Req.: a - draw and name water Profile

b - D.S water depth = 0.8 m/S

$n = 0.025$

Sol.:



$\because\ y_c = \sqrt[3]{q^2/g}$ for unit width

$q = \dfrac{Q}{b} = Q$

$\because\ Q = A \times V$

$q = Q = 4.8 \times (0.9 \times 1.0) = 4.32 \, m^3/S$

$$y_c = \sqrt[3]{\frac{4.32^2}{9.81}} = 1.23 \ m$$

$$y_n < y_c$$

For D.S

$$Q = A \times V$$

$$4.32 = A \times 0.8$$

$$A = 5.4 \, m^2$$

$$5.4 = \overset{b}{1} * y$$

$$y = 5.40 m$$

$$\because \ y_1 = 0.60 \, m$$

$$\because \ \frac{y_2}{y_1} = 0.5 \left[\sqrt{1 + 8 Fn_1^2} - 1 \right]$$

$$\because \ Fn_1 = \frac{V_1}{\sqrt{g \cdot y_1}}$$

$$V_1 = \frac{Q}{A_1} = \frac{4.32}{1 \times 0.6} = 7.2$$

$$Fn_1 = \frac{7.2}{\sqrt{9.81 \times 0.6}} = 2.97$$

$$\therefore \frac{y_2}{0.6} = 0.5\left[\sqrt{1 + 8 \times 2.97^2} - 1\right]$$

$$y_2 = 2.24\,m$$

$$\therefore \Delta x = \frac{\Delta E}{\Delta S}$$

$$\Delta E = E_2 - E_1$$

$$\Delta S = S_o - (S_E)_{av.}$$

$$\therefore Q = \frac{1}{n} \cdot \frac{A^{5/3}}{P^{2/3}} \cdot S^{1/2}$$

$$A = 5.4 \times 1 = 5.4\,m^2$$

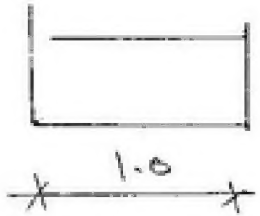
$$P = 5.4 \times 2 + 1 = 11.8$$

$$4.32 = \frac{1}{0.025} \times \frac{(5.4)^{5/3}}{(11.8)^{2/3}} \times S^{1/2}$$

$$S_o = 0.0011$$

$$E = y + \frac{V^2}{2g}$$

$$S_E = \frac{n^2 \cdot V^2}{R^{4/3}} \quad , n = 0.025$$



sec. No	y	A	V	E	ΔE	P	R (A/P)	S_E	$S_{E\,av.}$	ΔS ($S_o - S_{E\,av}$)	ΔX
1	2.24	2.24	1.93	2.43		5.48	0.41	0.0076			
					3.0				0.0044	0.0033	909.1 m #
2	5.4	5.4	0.8	5.43		11.8	0.46	0.0011			